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TEA RESEARCH INSTITUTE

OF CEYLON

Edited by

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THE TEA RESEARCH INSTITUTE,

St. Coombs, Talawakelle.

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The Laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries should be addressed to the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Telegraphic Address :—Research, Talawakelle; Telephone, Talawakelle 44 (Private Exchange). It is particularly requested that letters should not be addressed to officers by name.

EDITORIAL

DISEASES AND PESTS

IMPORTANT

A new eelworm (*Anguillulina pratensis*) has been discovered on the roots of mature tea where it is doing considerable damage. At present it is known on estates in two districts widely separated, and there is cause for suspicion that it occurs elsewhere. Estate Superintendents are requested to send specimens from suspected cases to the Institute for examination.

Affected bushes occur in patches. They look sickly and yellow, and do not as a rule carry a normal amount of foliage. The main roots appear normal; there is no distortion or other external symptom by which infection can be recognised, but parts of them, usually near the tip, will be found to be dead. Feeding roots are notably deficient.

The parts which are most useful for laboratory purposes are the junctions between the living and dead tissues of the main roots. When uprooting a bush for examination the roots should be dug out to their extremities. Only these roots with living and dead areas need be sent for examination.

Specimens should be accompanied by a statement indicating the number of bushes or area affected, whether feeding roots were abundant or otherwise, (specimens should be included if possible, particularly dead ones), and what other plants have been grown through the area during recent years. Other observations which may be considered of interest would be appreciated.

TEA TORTRIX

The recommendations of the Institute in regard to the relaxation of the regulations made under the Plant Protection Ordinance have been accepted. Though the Tea Tortrix still remains a pest declared under the above Ordinance, the regulations laid down in the notifications of April 20th, 1928, and April 28th, 1928, appearing in *Government Gazettes* Nos. 7639 and 7640 have been rescinded. It is therefore no longer *compulsory* to collect and destroy Tea Tortrix egg-masses, larvae and pupae or to send returns relating to such action to the Director of Agriculture.

ROLAND V. NORRIS.

Proceedings of the Sixth Conference of the Tea Research Institute of Ceylon held on February 13 & 14, 1939

Part II.

SOME MANUFACTURING PROBLEMS

ROLAND V. NORRIS, D.Sc., F.I.C.,
DIRECTOR

The Engledow Commission state in the part of their report dealing with the question of tea manufacture and quality: "It has been said that quality and manufacture are no job for the scientist but require constant trial and error work by someone with an inventive mind and a gift for cooking." It is perhaps unnecessary to add that the Commission did not support that point of view and it seems permissible to suggest that the results of many years' working on these lines has not led to any radical solution of the problems of tea manufacture. The retort may perhaps be made that scientific methods have not been appreciably more successful. Without committing myself as to the justification for that retort it is fair to point that so far as Ceylon is concerned science has not as yet had a very long innings. It may also be claimed that although nothing revolutionary has been evolved in the past ten years in regard to manufacture, the various processes are gradually becoming more systematised and a considerable amount of information has been acquired in regard to the conditions under which these processes should take place. But progress is hindered from the scientific approach, by the lack of knowledge we have as yet acquired in regard to the chemical nature of these constituents of the leaf which undergo change during manufacture I referred to this in my address to you this morning when I told you that financial arrangements were practically complete for a five-year programme of work on this subject, the funds being jointly provided by India, Java and Ceylon.

Five-year programmes are rather popular at the moment but it is not an uncommon experience to find an extension of time is required. I stress this because I do wish you to realise that the field of work is an exceedingly difficult one, and I am sorry that, in response to Mr. R. C. Scott's appeal to the Tea Research Institute over the wireless the other night "Let us know how to influence

the Chemical side of teas as soon as possible," I can only say that "as soon as possible" may prove to be a somewhat disappointingly long time.

But the fact that this work will be mainly carried out in Europe does not mean that the subject is receiving no attention here or in the other producing countries. Mr. Lamb has in fact already obtained some very interesting results in regard to tea tannin. I am not going to give you details because they are highly technical, but the work is receiving confirmation from other sources and will in due course link up with the research carried out at home.

A point that must strike any observer is the wide variation in manufacturing conditions which occurs between different factories. This applies to almost every branch of manufacture, withering, rolling, fermenting or firing. Does this mean that in each of these processes there is a very wide margin of latitude within which the conditions are of little importance? I do not believe this to be really the case, but it is of some importance, I think, to find out where latitude can safely be allowed and where control must be most strictly applied. This would give a direction to research which would naturally be concentrated first of all on these vital points. I expect some of you gentlemen have very definite views on this issue and I hope you will let us know what they are.

That these wide variations in manufacturing practice do exist can be illustrated from the results of an enquiry made by the Proefstation West Java into rolling conditions in 166 factories in Java. In looking through the information supplied one finds that the number of rolls given varied from 2 to 8, the duration of a roll from 20 to 80 minutes, and the amount of dhool separated from the first roll from 2.2 per cent to 75 per cent. I do not know whether in Ceylon we can find such wide variations as these figures represent. I am inclined to think, however, that a survey of manufacturing conditions in Ceylon factories, and a careful analysis of the data obtained, would give information of value from which useful conclusions could perhaps be drawn.

Such a survey might be suggestive, moreover, in regard to the possibility of any radical modification in tea manufacture. In recent years only two such modifications seem to have received any serious trial, the substitution of a crushing or cutting type of machine for the conventional roller, and the use of unwithered leaf. From information recently received it seems there are a number of factories in North-East India using unwithered leaf in connection with a cutter of the Legge type. After passing through the cutter, the leaf may receive two or three light rolls in an ordinary roller, and is then

ready after a very brief, or sometimes no, fermentation indeed for firing. The latter, I understand, requires particular care and it is also of great importance to avoid any over-fermentation. I believe this process is in use chiefly at low elevations and is not employed in the Darjeeling District. The importance of the process, assuming that satisfactory teas can be produced, lies in the saving of time in manufacture and the reduced cost of this.

As an example of the crushing type of roller, the Clivemeare roller may be referred to. Those of you who will be at St. Coombs tomorrow will be able to see a small machine of this type. With this machine withered leaf is used though a rather softer wither is taken than for normal rolling.

After passing through the Clivemeare roller the leaf receives two normal rolls, the object of the latter being largely to improve the appearance of the leaf. Fermentation proceeds more quickly than with normally rolled leaf and very bright and even infusions are obtained with strong coloury liquors.

In both the processes to which I have referred the difficulty has been that of appearance. I have no personal experience with the cutting type, but although our experiments with the Clivemeare machine has certainly greatly improved the appearance of the leaf in comparison with what was first made, I am afraid, however, Colombo buyers still think it is not up to par in this respect. London, however, seems to attach less importance to this character and of two trial invoices sent home for sale last year the Clivemeare tea realised on the average a premium of 1d. a pound over the normally manufactured tea. Work with this machine is continuing and we are now preparing another invoice for the London market.

I have referred in some detail to these two processes, because they do indicate that radical changes in manufacture are not impossible.

It was no doubt with this thought in mind that Mr. Scott in his broadcast appealed to us not to work with too stereotyped methods. I should like to be able to satisfy him on this point but there are certain practical difficulties to overcome. If expense could be disregarded we could of course try out a much wider range of equipment and experiment more fully with modifications of existing plant. Though we have been fortunate in securing the assistance and co-operation of the engineering firms interested in tea machinery, work of this character is costly and, as I have said before today, our resources both in regard to finance and staff are limited.

You will have seen from *The Tea Quarterly* for last October, the description of the rolling experiments initiated by Mr. Lamb, and these are to continue so as to include all seasonal variations. I think these experiments will give very useful results in that they will provide information in regard to the correct selection and use of different batten types and generally indicate the best working conditions of rollers as they exist today. But you will have gathered from my earlier remarks that it is in regard to rollers that I expect some fundamental change will first be made. It is true that various improvements and refinements have been made to these machines but if we remember that fermentation begins in the roller we must admit that these machines are very ill adapted to secure one of our chief requirements, that is a bright and *even* infusion.

Theoretically it seems to me one of two things should happen during rolling so far as the fermentation of the leaf is concerned. Either the initial treatment should be so drastic that fermentation is almost immediately set up throughout the whole bulk of leaf, or else rolling conditions, *i.e.*, temperature, must be adjusted so that fermentation is inhibited until the mechanical functions of rolling have been completed when each dhool can be set out to ferment under the optimum conditions. The first condition is very largely achieved in machines like the Clivemeare, but is impossible in the conventional roller. Attempts have been made to attain the second condition by various cooling devices applied to the roller jacket. These, though not yet entirely successful, are promising enough to warrant further investigation and development. Cooling, however, is not a cheap process and the cost of this may be uneconomic.

These considerations lead me to comment on a feature of factory layout very common in Ceylon which I believe to be unsound. I refer to the practice of carrying out fermentation and rolling in the same room. The conditions required for the two processes are quite different. For rolling we want as low temperatures as we can conveniently achieve, while for fermentation there is ample evidence, as Mr. Finley will confirm, that a temperature of slightly over 70°F. is desirable. The space required for fermentation is not very large and if a separate room be provided for this purpose the question of temperature regulation would present few difficulties.

Fermentation periods are usually either fixed according to a settled programme or determined on each occasion by the judgment of the teamaker. A means is required by which the accuracy of these programmes can be effectively checked. It seems likely that this is now available. Mr. Whitehead will, I hope, describe to you during our discussion a piece of apparatus by means of which a considerable number of small dhool samples can be quickly dried

under conditions of temperature and time which conform closely to those of normal drying. Such samples can be taken from each dhool at various time intervals and from the examination of the dried teas it can readily be decided what fermentation periods are required and the best order in which the dhools should be fired. It seems to me this should provide a most valuable means of checking up fermentation programmes.

Before leaving the question of fermentation, I might mention that laboratory investigations are in progress in regard to the mechanism of fermentation. Interesting results are being obtained by Mr. Sreerangachar which seem likely to clear up several hitherto obscure points.

Passing on to firing, marked improvements in factory practice have been made and firing is now generally much better organised and controlled than was the case a few years ago. Firing temperatures seem, however, to fluctuate somewhat from one extreme to the other. A few years ago there was a demand for high inlet temperatures under the mistaken ideas that this would put an end to the complaints of soft teas which were somewhat frequent at that time.

At the moment there seems a tendency to swing in the other direction and to try out lower temperatures, and the Institute has been making a comparison between teas fired at 160°, 190° and 210°. We have not sufficient data as yet to give any conclusive answer. I can, however, say that the preliminary results with 160° are promising and that, any rate, teas dried at this temperature seem regularly to be preferred to those dried at 210°.

Following naturally on drying is the question of maturing and storage. Experiments have been in progress to determine how far this is influenced by the moisture content of the tea. For this purpose a standard was taken of tea dried at 3 per cent, moisture content. A portion of this tea was further dried to 1.7 per cent, while in other portions the moisture content was raised to 5, 6, and 7 per cent respectively. The various samples were then stored for four weeks and sent for report. So far the tea stored at 3 per cent moisture is preferred and valuations have progressively declined as the moisture content figure was increased from 5 to 7 per cent.

I must omit details of various other experiments on packing materials, tests of machinery, etc., to refer to some interesting views which were put forward some months ago by Mr. Benton, the Bacteriologist of the Tocklai Experimental Station.

Briefly, Mr. Benton's suggestion is that the dull, soft, teas with poor infusions which are often a feature of monsoon leaf and frequently attributed to over-fermentation, can be almost, if not entirely, avoided by more careful attention to factory hygiene, and efficient sterilisation of factory plant, together with certain other precautions which I shall detail in a moment.

The leaf when plucked is naturally not sterile and contains on its surface, like every other exposed object, numerous bacteria, perfectly harmless from the health point of view, but capable when in sufficient numbers of unfavourably influencing the normal course of fermentation.

If the leaf be wet when plucked and the surface moisture not sufficiently rapidly removed, this favours the multiplication of such bacteria. This will be particularly so if the temperature be moderately high as when wet leaf is too tightly packed in the plucking baskets.

Again if the factory floor and machinery, particularly rollers, roll-breakers and wooden containers, are not kept most scrupulously clean, the residues which may accumulate provide an obvious cause of infection.

Mr. Benton suggests, therefore, so far as machinery and floors are concerned, more drastic methods of sterilisation, *i.e.*, by flaming.

I may say, without casting any aspersion at all on factory conditions in North-East India, that in Ceylon we have not to contend against some of the difficulties with which they are faced. Our temperatures are lower in the first place and, with our much harder withers, there is not the same expression of juice to percolate into cracks and crevices and leave deposits there. Consequently it is probably considerably easier for us to keep our plant in a reasonably clean condition. While this may suggest that less drastic means of partial sterilisation would suffice in the average Ceylon factory, particularly up-country, we should not ignore the fact that valuable improvements might be effected by more attention to these matters. Some preliminary tests on this subject have been carried out by the Institute at St. Coombs and we were also able to arrange for similar trials to be made by an estate at a lower elevation. The earlier tests at St. Coombs showed little difference between teas made after careful flaming of all plant, etc., by means of a blow-lamp and those made without such precautions. In a repetition of this work, however, the teas made under what for convenience I may call sterile conditions were definitely preferred to the controls.

In regard to the estate experiment at low elevation, though I have not yet full details, the superintendent reports he considers

a definite improvement has been brought about in the teas by the use of the blow-lamp. There are therefore indications which cannot be ignored and must be further investigated. Unfortunately I do not consider the blow-lamp which has been designed for use in Assam as particularly suitable for Ceylon factories. In Assam withering is carried out in a separate building, and the main factory is relatively fire-proof. This does not apply here and I think something much safer will have to be devised if it should eventually appear that flaming is advantageous.

Meanwhile, however, I would stress the importance on general grounds of the greatest possible attention being paid to cleanliness and factory hygiene. The Institute has persistently drawn attention to this point and there has in consequence been a marked improvement, I think, in factory conditions. But this must be maintained. Engineering firms can do much to assist by improvements to plant to facilitate handling and transport of leaf and by greater attention to factory layout. We are anxious to co-operate with such firms in every possible way to achieve this purpose. May I suggest that we could also possibly give some assistance to agents and superintendents in regard to such matters. It is not very often that the plans for the construction of a new factory, or the reconditioning of an old one, are sent to us for comment, and quite frankly I think this is a pity. If improvements are to be effected there must be a pooling of all our resources.

Gentlemen, in the time at my disposal I have necessarily had to omit any reference to many of the activities of Mr. Lamb's division. I have made no reference to the routine work it has to carry out for other departments, for example the manufacture and analysis of leaf from manurial and physiological experiments, the devising of methods for the manufacture of individual bush samples of leaf, the latter being of fundamental importance to the work on selection. This division has also its full share of normal advisory work which I think has been of distinct help to the Industry. It has had perhaps more than its share of *ad hoc* problems which have had to be dealt with to the interruption of the regular programme of research. You are all quite reasonably impatient for results of immediate practical application to be forthcoming. But though we may lay ourselves often to criticism, our policy, and I am convinced it is a sound policy, is that we should not rush to give recommendations merely for the sake of putting out so-called results, but should rather wait until we can at any rate convince ourselves, and I hope you at the same time, that any advice we give is based on definite experimental evidence which we consider reliable. I believe by so doing we are acting in the best interests of the Industry.

Gentlemen, I began my address by a quotation from the Engledow Report; I will finish by another which is as follows: In reference to research on manufacture the report says: "The carrying out of many stages . . . . would in practice be very lengthy and intricate . . . . Great care must be shewn in deciding which experiments to make on quality; only a few can be carried out at one time, and for these ample resources and a considerable space of time are necessary." I particularly commend the concluding line to your attention.

HEAT IN RELATION TO MANUFACTURING PROCESSES

D. W. FINLEY, B.A., B. Sc. (Oxon.) A.M.I.B.E.

Factory Superintendent,

Kirkoswald Estate, Bogawantalawa.

When Dr. Norris asked me to speak to you this afternoon, he suggested that the subject should be as general as possible, and that technicalities should be avoided. I make no apology, therefore, for generalities.

One underlying principle behind three of the important processes of tea manufacture concerns the use of heat. That "heat is the enemy of quality" has always been quoted as one of the most important sign-posts to the goal of good manufacture; in addition it is a saying that has stood the test of time. And yet the more that is understood about withering, fermenting, and firing, the more it is realised that heat — this so-called enemy — must be present for successful manufacture.

Throughout this paper a careful differentiation is made between 'heat' and 'temperature.' However loosely these terms may be employed colloquially, in scientific parlance they have quite distinct meanings. Heat is a quantity and temperature is a quality. It is the difference between a bucket of red paint (which is enough to cover a given area) and the colour red which is simply an abstract quality, and may exist in different degrees such as scarlet, crimson or maroon.

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* The Institute does not necessarily endorse the views expressed in papers contributed by persons other than members of the Staff.

Temperature — the quality — is measured by degrees, but heat is measured by the British Thermal Unit, (or B.T.U.) the quantity of heat required to raise one pound of water through one Fahrenheit degree of temperature. Nowadays we are familiar with the term 'calorie' in connection with various forms of diet. 250 medical calories are approximately equivalent to one B.T.U.

It must always be remembered when considering the measurement of temperature, that withering leaf and fermenting leaf, both containing moisture, will 'feel' a lower temperature than the temperature of the air. In practice this resembles the wet bulb temperature of a hygrometer, particularly in the case of moist fermenting leaf.

WITHERING

Turning from the general consideration, we can now consider how these effect the various processes of manufacture. Most factories in Ceylon employ fans for withering, at any rate during part of the year. But in any case, whether a fan wither or a natural wither is being used, heat is actually necessary. In order to remove water either by boiling or by a process of slow evaporation at a lower temperature than boiling, heat must be supplied to the container of the water.

In the case of withering leaf, a definite amount of heat will have to be supplied in the lofts to allow the evaporation that takes place there to be completed. Heat must therefore be applied continuously, over about 17 hours.

The change of state from liquid water to water-vapour requires a tremendous amount of heat. In fact it takes about 1,000 times as much heat to evaporate one pound of water as it does to raise it through one degree Fahrenheit, say 200°-201°F. In the case of a fan wither this heat is supplied by means of the driers, using hot air as the medium. In the case of a natural wither, the heat is also supplied by means of the atmosphere, in the sense that the air is cooled down. In both cases the heat is probably supplied indirectly The leaf supplies the heat for the evaporation and as soon as the leaf has cooled sufficiently it will reabsorb heat from the atmosphere. This means that when equilibrium is reached, the leaf will always be a little below the temperature of the air.

It may be that this is the explanation of the curiously accurate 'teamaker's judgment,' a judgment which is so much a matter of experience that few teamakers can explain it. Merely by runing their hands over withered leaf on the tats, they can estimate the moisture content of the leaf surprisingly accurately. It is a

noticeable thing that withering occurs more rapidly at first, and slows down as soon as about 56 per cent moisture content is reached. Heat is being taken from the leaf more slowly after that point, consequently the leaf cools down less noticeably. Leaf that is withering rapidly feels very fresh and cold, but when the wither slows down it feels warmer.

There is a second effect — the effect of the rate of wither on the distribution of moisture in the leaf itself. Both before and after withering, the stalk contains about 10 per cent more moisture than either the leaves or the bud.

These are typical figures for leaf from a field about 2 years old.

	Before withering	After withering for 17 hours
Stalk ...	84.5% water	65.2% water
Bud ...	80.1%	50.8%
First leaf ...	75.3%	49.3%
Second leaf ...	75.6%	51.9%
Average of flush ...	78.1%	53.6%

These figures show that the stalk acts as a reservoir, a conclusion that can be confirmed as follows. If, before withering takes place, the flush is separated by breaking off the first leaf and bud, leaving the stalk and second leaf, it will be found that the stalk has acted as a reservoir for the bud and leaves, and that evaporation occurs mainly through the leaves. This has a very important effect on withering. If the hygrometer difference rises too high in the lofts, evaporation can take place so quickly that the leaves are often shrivelled up at the edges although the stalk is still definitely under-withered. In this case withering has occurred so rapidly that the minute capillary veins that are used to feed the sap from the stalk to the leaves are dried up, and water is virtually trapped in the stalk.

To effect a wither in a given time, say 17-18 hours, a given amount of heat must be supplied. If the wither is not quick enough, either the hygrometer difference can be raised or more air must be passed through the lofts. Either methods increase the quantity of heat available in a given time. There is a popular impression in Ceylon that a hygrometer difference of about 6°F is necessary for a fan wither. It is possible to wither at 2° or 3°F in 18 hours by using more air than is normal, say about 35,000 cubic feet of air per minute in each loft. The latter method has the advantage that if a change in the weather conditions occurs and is not noticed by the night staff, harmful hygrometer differences are rarely reached.

The rate of withering is controlled by the rate of supply of heat. As the air takes up moisture, heat is taken from the air so that the air is cooled down. The relationship between moisture contents and actual water evaporated per 100 lbs. of green leaf is given in the the following table:—

	Total	Dry matter	Water	Moisture contents	Evaporation
Green leaf	100 lbs.	22 lbs.	78 lbs.	78%	—
Withered leaf	(47.8)	22 lbs.	25.8 lbs.	54%	52.2 lbs. (withering)
Made tea	(23.9)	22 lbs.	(1.9) lbs.	4%	23.9 lbs. (firing)

In the second column of this table, it is assumed that the weight of dry matter is not changed by withering or firing, an assumption that is very nearly true. The total weight is calculated after considering the average moisture contents; and the number of pounds of water evaporated obtained by subtraction.

Taking average figures, for every 100 lbs. of green leaf, 52 lbs. of water are evaporated by withering. In one test the incoming air was at 73°F with a hygrometer difference of 6°F and the air exhausted from the lofts was at 70°F with a difference of 3°F. By looking up the appropriate hygrometer tables, it is found that the air has gained (correcting for altitude), about three-fourths-of-a grain of water per cubic foot before leaving the loft. Since about 20,000 cubic feet of air were passing per minute, the air would remove about 125 lbs. of water per hour. The leaf spread had about 1,250 lbs. of water to be evaporated. If a uniform rate of withering had been maintained the leaf would have been ready in about 10 hours. Actually the rate of withering decreases.

Air leaves the lofts containing only 60-70 per cent of the maximum possible amount of water. Some recent Java experiments have shown that both growing and withering tea leaves are surrounded by an atmosphere of moisture. It is probable that this fact contains the explanation of the inefficiency of withering. There is a tension in this atmosphere rather like surface tension — the skin effect on the surface of water. This is strong enough to float a needle. The vapour tension round tea leaf can be broken down and partially dispersed by warming the leaf, so that at a higher temperature withering is easier. If the leaf is spread thickly, it is even more difficult than usual to disperse the film of water vapour

and the Java experiments have shown that the unevenness in different individual specimens of apparently evenly withered leaf is in fact due largely to the position of the leaf on the tats. They found by statistical analysis that only about 10 per cent of leaf has a really good chance of withering evenly and 25 per cent was definitely badly placed on the tats. I am not aware if this work has been followed up with open woven hessian, but in theory the freer the air movements the more readily will the skin of water vapour surrounding the leaf be broken down.

ROLLING AND FERMENTING

Dr. Norris has already dealt with several points in this connection. The important point is that the rollers generally employed in Ceylon combine two processes: twisting up of the leaf and the starting off of fermentation by the exposure of the tea juices to the air. Unfortunately in the present type of roller the starting off of fermentation tends to be progressive instead of simultaneous. Consequently the brokers are constantly reminding us that we have 'some greenish leaf.' This simply means that some part of some dhools have not been fully fermented. As Mr. Lamb has told us, the best way to overcome this with the *existing* rollers is to choose for the first rolls, a type which will allow very heavy rolling with a very small dhool out-turn. This depends largely on the battens. A type of roller recently put on the market allows a pressure of up to 1,000 lbs. without turning out more than 12 or 13 per cent first dhools, and is ideal for first rolls. On the other hand, the same spring on a popular type of roller produced over 50 per cent first dhool. The difference was simply a matter of batten type — the first type being a 'twisting type' and the second a 'cutting type' of batten.

It seems generally agreed that the Clivemeare roller, although it may have some disadvantages because of the appearance of the made tea, has always effected a marked improvement in the evenness of infusion. This is due to the simultaneous initiation of fermentation. The leaf can afterwards be put through the ordinary roller to twist it. On the other hand there are two methods of 'cold-rolling' which in effect allows the disintegration of the leaf without starting fermentation. By both these means the processes of starting of fermentation and twisting up of the leaf can be separated. At St. Coombs, some leaf was on one occasion kept for about 8 hours without appreciable fermentation. A very vital objection to fermenting on metal trays is that during early morning manufacture the generation of heat by fermentation is greatly delayed.

In the case of fermentation therefore, heat is required. The requirements are better known and understood than in the case of withering, where the ideal requirements are almost a matter of guesswork. For fermentation recent authorities favour the range 65°-75°F., and there is a marked preference for 70°-72°F. using air as nearly saturated as is practical. Fortunately for most up-country factories, the temperature of the fermenting room so rarely exceeds 70°F. that in practice cooling would never be necessary. This would make such a scheme quite reasonably cheap, and no doubt one of the most important immediate steps in factory control will be along this line. Obviously there can only be one *ideal* temperature for fermentation and, after this is found by experiment, it should be maintained. An even time of fermentation would follow, with considerable assistance to organisation.

FIRING

Firing is the second important process of evaporation. It is worth while stressing this point most strongly, because of the persistence of the fallacy that the hourly out-turn of a drier in lbs. of made tea is directly related to the performance of the drier. The out-turn is affected from day to day by several factors, particularly the moisture contents of the dhools fed. But the pounds of water evaporated per gallon (or pound) of fuel used, should be constant for the same conditions of inlet and outlet temperatures, irrespective of varying moisture contents. In just the same way as moisture content of withered leaf is the figure now coming into general use, instead of the meaningless figure of percentage wither, so the evaporating capacity of a drier should be used rather than the out-turn in pounds of made tea.

A table is given showing how moisture content affects the out-turn.

Made tea out-turn for different evaporating capacities of driers at different moisture contents.

Made Tea % on withered leaf	Equivalent moisture contents of withered leaf	Pounds evaporated per hour				
		150	175	200	225	250
50	50%	150 lbs.	175	200	225	250
48	52%	139 „	162	185	208	231
46	54%	128 „	149	171	192	213
44	56%	118 „	138	157	177	197
42	58%	109 „	127	145	163	181
40	60%	100 „	117	133	150	167

The process of firing is not a particularly efficient one in practice. Not only are there losses up the chimney between 12 and 15 per cent, but there are losses in the drier itself because the air leaving the drier is generally at about 115°-120°F. and is rarely much more than 40 per cent saturated on a pressure type of drier. At the same time it seems to be well established that the exhaust temperature should always exceed 110°F to avoid 'stewing' teas. Consequently the air can never be very highly saturated, even if the design of the driers is changed.

With liquid fuel the production of a steady flame is quite simple and the best possible combustion is easily obtained from the fuel. But with coal and firewood a tremendous amount of heat may be lost through bad stoking and incomplete combustion. Various factors affect the results. With the usual 36 in. logs of firewood a big draught has to be maintained to overcome the damping effect to the fire when stoking. If the logs are cut to half or third lengths, the draught can be cut down considerably, regulating by means of the ventilators situated under the furnace doors. Cutting to 12 in. lengths, stoking is so easy that I have known a saving of over 40 per cent although the corresponding saving with 18 in. lengths was not so great. With red gum the output was increased to about 1,200 lbs. of made tea to the yard of firewood.

Induced draught is of great assistance in maintaining an even furnace temperature and in saving fuel. Generally induced draught is supplied with too big a suction, partly to cope with the cold stove and chimney when lighting up. For normal running the fan should be closed as far as possible consistent with good combustion. With liquid fuel too big a draught causes the flame to flicker and jump, and also causes the flame to tail off into a series of sparks. Low pressure burners are economical, and require a very small amount of air. It is a common mistake of coolies to have the small inspection doors and the door underneath the burner fully open. The latter door is for directing the flame. By admitting air, the flame can be lifted. Any excess air required should be admitted by the circular louvres round the burner. The makers of the Wallsend low pressure burners recommend that the flame should be such that smoke can just be seen from the chimney. After a long series of experiments I found that the most economical flame is one with which the least reduction of draught causes smoke.

With either wood or coal, a shallow even fire is the most economical. Although furnaces are often bricked up too much, it must be realised that if carelessly used, after the removal of some of the bricks, a larger grate area allows more waste than a small area, and the draught associated with the larger area must be particularly carefully supervised.

Superintendents are often asked to revise estimates for firing costs when a conversion is made from one kind of fuel to another. This can be done reasonably accurately since all fuel has a definite "calorific value." That is to say a fixed weight of wood or liquid fuel or coal will produce a definite amount of heat. In practice the heat produced by a given fuel is below the theoretical value, and this particularly applies to damp firewood and to coal used with bad conditions of stoking, draught, or dampness. It cannot be too strongly emphasised that a rough firewood store shed is a very much worth while proposition to the estate. The out-turn per yard can be calculated from the following tables, which show the average weight of wood to a yard, and the cost per pound of made tea. The table assumes continuous firing, that the firewood is stored under rough cover, and that it is well stacked and well cut.

Weight per yard		Approx. cost per lb. of made tea			
		(a)	(b)	(c)	(d)
Red Gum	1000 lbs	0.46 cts.	0.40	0.37	0.25
Blue Gum	925	0.50	0.43	0.40	0.27
Rubber	800	0.58	0.50	0.47	0.31
Grevillea	750	0.62	0.53	0.50	0.33
Toonah	675	0.68	0.59	0.55	0.37
Acacia	650	0.71	0.62	0.58	0.38
Jungle wood	650-850	0.71-54	0.62-.47	0.58-.44	0.38-.29
Albizzia	500	0.92	0.80	0.75	0.60

Notes.—All costs are worked out at a charge of Rs. 3/- to a yard of firewood, and for a modern type of drier stove. They are based on the fact that continuous firing with any firewood under a given set of conditions, will show a given out-turn in pounds of made tea to a *pound* of firewood.

(a) Without induced draught, and firewood 36 in. lengths, out turn 0.65 lbs. tea/lbs. firewood.

(b) Without induced draught, and firewood 12 in. lengths, out-turn 0.75 lbs. tea/lbs. firewood.

(c) With induced draught, and firewood 36 in. lengths, out-turn 0.80 lbs. tea/lbs. firewood.

(d) With induced draught, and firewood 12 in. lengths, out-turn 1.20 lbs. tea/lbs. firewood.

Whilst some of these figures are theoretical calculations, they all correspond closely to actual figures from my own records, and others produced by Messrs. Davidson & Co. Of course the costs

will be proportional for different costs of firewood, and for different out-turns of made tea to a pound of firewood.

If the conversion from wood to liquid fuel or coal is contemplated, the following figures, supplied by the Shell Co. may help.

	Liquid fuel	Equivalent coal	Equivalent firewood
Natural draught	1 gallon	22.95 lbs.	65.4 lbs.
Induced draught	1 gallon	18.18 lbs.	52.7 lbs.
			30 lbs for 12 in lengths

From these figures new costs can be worked out. For example, with red gum weighing 1,000 lbs. per yard, one yard will be equivalent to $\frac{1,000}{52.7}$ gallons of liquid fuel, *i.e.*, about 19 gallons.

If one yard of gum costs Rs. 3.00 and liquid fuel costs 30 cents per gallon the cost of firing will rise to about Rs. 5-70 for the same weight of fired tea.

On the other hand one yard of the same firewood will be equivalent to about 345 lbs. of coal, which at Rs. 37-50 per ton costs Rs. 5.77. In both cases induced draught is considered.

The last point I should like to make is this. The best firewood is a heavy firewood like red gum. According to Mr H. C. King in *The Tea Quarterly*, 1935, planting gums at 6 × 6 feet (approximately 1,000-1,200 per acre) and felling every 12 years, 50 acres of gums are required to supply fuel for 500 acres of tea in bearing. This figure is based on 400 yards to an acre. I believe personally that the yield per acre is a little higher than this in many cases, and the required acreage of fuel block lower than is mentioned. Shade trees often account for a good many thousand trees.

In conclusion, I would like to express my thanks to the Directors of the Bogawantalawa District Co., to the Tea Research Institute, to Messrs. Davidson & Co., and the Shell Co. of Ceylon all of whom have been of great assistance in the matter of collecting data for this paper.

DISCUSSION

Mr. C. W. Newton said it had been suggested that teas made by the Clivemeare rolling process did not keep well and asked if there were any proof of this.

Dr. Norris in reply said he did not think there was any real evidence in regard to their keeping qualities, though statements of a general nature had been made. The only commercial invoices sent to London were the two experimental invoices he had referred to. Of the numerous small samples which had been sent to London some, at any rate, had been preserved for a considerable time and had kept well.

Mr Morford said he had had the opportunity of using both the Clivemeare roller and the Legge cutter. Dr. Norris had referred to the possibility of some major modifications in tea manufacture and the thing that had struck him when using the latter machine was the advantage of eliminating withering. Due to this, teas made in the Legge machine were ready to leave the factory by 1 p.m. on the day the 10 o'clock leaf was plucked. After a little experience had been gained, all these teas were reported on as being very brisk and very bright and they had sold above the market average. Legge manufacture was not continued, however, since the blenders found that the type of tea produced caused difficulty in packing and the purchase of large quantities would involve drastic alterations to their packeting machines.

There were two major difficulties about this type of manufacture. The moisture content of the leaf at the time it went to the drier was probably about 70-75 per cent. It was impossible for the existing type of driers to deal satisfactorily with such leaf, particularly as the out-turn of the cutter was in the region of 1,000 lbs. per hour. Again, the cut tea fermented within 20-25 minutes and it was impossible to complete drying quickly enough, with the result that some of the tea was overfermented by at least half-an-hour.

Mr. Morford said he referred to these experiments as they provided some indication that withering might not be as important as sometimes thought. It was possible to obtain good teas without withering and this could be an important point in factory construction. Elimination of withering also removed one possible source of bacterial infection and Mr. Benton had attributed the success of the "no wither" system in the Dooars very largely to this cause.

Mr. Wilfred Rettie said that Dr. Norris in his address had referred to the question of drying at lower temperatures and he thought this was extremely important. It might be of interest therefore if he described an experiment carried out on an estate in which he was interested during the monsoon. The experiment made, using a 3 feet E.C.P. drier, was really a repetition of one carried out 20 years before but modern drier fitments made it more accurate.

Two firing temperatures had been employed, namely the normal firing temperature of 185° and a temperature of 165°. In the former case the tea was put through the machine in 20½ minutes, in the latter in 31 minutes.

Identical leaf had been used in each case and two comparative invoices manufactured for sale in London. Samples were examined in Colombo and the verdict given in favour of the normally fired tea. He had himself been in London when the teas reached home and had tested the samples with the brokers. Again everyone was unanimous that the normally fired teas were the better. By the time the teas were sold, however, about six weeks later, the position had been reversed and the teas fired at 165° secured three-farthings a pound more than those fired at 185°. This would suggest that the firing temperature had had an influence on the way in which the tea matured.

Mr. Rettie went on to say there were two or three points arising from Mr. Finley's interesting paper to which he wished to refer. Mr. Finley had stated that for many years one of the main signposts to successful manufacture had been labelled "Heat is the enemy of quality." This statement appeared to indicate rather a lack of discernment on the part of planters. He presumed Mr. Finley really meant unnecessary heat.

Secondly, Mr. Finley had stated that in the case of natural withers the heat of evaporation was taken from the leaf itself. Was this correct? If the leaf provided its own heat for evaporation, it would freeze long before it became withered. He suggested the air used in natural withers provided the heat just the same as in artificial withers.

Again, Mr. Finley had said that the improvement in fermentation so clearly produced by the Clivemeare roller was due to the sub-division of the leaf particles and the rapid initiation of fermentation by the exposure of the tea juices to the air, only the latter process requiring heat.

He wished to ask if it was necessarily a good thing if fermentation throughout a batch of leaf started simultaneously — the batch could not be fired simultaneously.

Lastly, Mr. Finley had referred to the persistence of the "fallacy" that the out-turn in pounds of a drier was directly related to the performance of the machine.

He (Mr. Rettie) did not quite see where the fallacy arose. It was well-known that the greater the moisture the less the dry leaf, but there were standards in Ceylon and so long as one had to deliver

so many pounds of dry tea to the market so long would a drier be required to turn out so many pounds of dry tea per hour.

Mr. Finley in reply said that in regard to the first point raised he entirely agreed with Mr Rettie and he was sorry he had not made the point clear. Heat was rather like electricity — dangerous when uncontrolled. It was certainly more correct to say "*Unnecessary* heat is the enemy of quality."* Without this qualification the phrase was misleading.

On the second question also his meaning was exactly what Mr. Rettie had stated. In both fan and natural withers enormous quantities of heat were required to effect the necessary evaporation. In both cases the water evaporated at the leaf surface. The leaf thereby cooled down and reabsorbed heat from the air. In this way a state of equilibrium was reached which explained why the leaf was always a few degrees cooler than the air itself. That the air was cooled could easily be seen by taking the temperatures of the incoming and outgoing air in the loft. In both a natural and a fan wither the leaf was cooled. Such cooling was less marked in the case of a natural wither, probably due to the greater quantity of air flowing through the loft.

With regard to fermentation, he appreciated Mr. Rettie's point. Rollers of the type of the Clivemeare and McKercher greatly improved infusions. Whether this was entirely due to the rapid and simultaneous setting up of fermentation he was unable to say. Even with the Clivemeare roller however progressive dhools were taken. Moreover, recent work at St. Coombs suggested that different parts of the flush had different enzymic activity and consequently the rate of fermentation would not be uniform. It was, he believed, a common factory experience that the wiry leaf took longer to ferment than the first dhools, *i.e.*, longer to reach the teamaker's standard of evenness in fermentation. Possibly Dr. Norris would be able to give more detailed figures.

In connection with drier out-turns he merely wished to stress the point that it would, in his opinion, be advantageous if the drier were referred to in terms of the number of pounds of moisture it could evaporate per hour instead of the number of pounds of made tea it could turn out. The former figure was a constant for a given machine over widely varying conditions, the latter would vary from factory to factory under each set of conditions, particularly with changes in the moisture content of the dhools. Mr. Finley referred to the case of a new drier recently put on the market where the

* Mr. Finley wishes to make an acknowledgment to Messrs. Elliott and Whitehead's book *Tea Planting in Ceylon* where this important distinction was first drawn.—Ed.

makers stated the capacity of the machine in terms of the pounds of moisture that could be evaporated but related this to the number of pounds of dry tea obtained for a given moisture content of the leaf.

Mr. Huntley-Wilkinson said it would be interesting to know in a normal rolling programme of $2\frac{1}{2}$ to 3 hours, what proportion of the leaf was fermented in the rollers.

Dr Norris said it was not possible to give exact figures. The dhool out-turn and the time required to complete fermentation of each dhool would however give an approximate indication. In the later dhools probably at least 80 per cent of the fermentation had taken place in the roller.

It seemed probable that better results would be obtained if fermentation could be carried out under fixed and constant conditions. This could not be achieved with a normal roller and by no means completely with a roller such as the Clivemeare. Fermentation was set up more nearly simultaneously in the latter type, but there still remained the difference due to the different portions of the leaf which, as Mr. Finley had pointed out, did not necessarily ferment at the same rate.

Mr. S. F. H. Perera asked whether the quality of low-grown and mid-grown tea could be improved by the installation of air-conditioning plants in factories.

Dr. Norris said an experiment had been carried out at St. Coombs where leaf brought up from a low-country estate had been manufactured and compared with tea from a portion of the same batch of leaf manufactured in the estate factory. The tea manufactured at St. Coombs was considerably the better of the two. A similar result had been obtained in an estate experiment on similar lines. He had no reason to think that anything except the different temperature conditions contributed to these results. There was, therefore, some reason to think that air-conditioning in factories at low elevations might result in an improvement to the tea made. It was impossible at the moment to indicate how the right conditions could be economically achieved. As had been pointed out in a recent article in *The Tea Quarterly* (1938, Vol. XI, pp. 151-154) conditioning of separate fermenting rooms presented no special difficulty; rollers could also be cooled, but withering was a much more serious problem. The Institute was in touch with firms interested in air-conditioning in the hope of obtaining further data on the subject.

Mr. E. C. Cameron asked Mr. Finley if he were right in deducing from the figures given that firing by liquid fuel was slightly cheaper than the use of coal.

Mr. Finley replied that if the prices quoted were accepted, namely liquid fuel at 30 cents per gallon and coal at Rs. 37.50 per ton, the firing costs given in his paper would be found approximately correct.

In further reply to Mr. Cameron who asked if these calculations were worked out on theoretical considerations or practical tests, Mr Finley said that they were based on theoretical grounds but had been confirmed by a large number of experiments carried out both at St. Coombs and by engineering firms.

DISEASE IN NON-PRODUCTIVE BUSHES

C. H. GADD, D.Sc.

A statement that all diseases of the tea bush ultimately lead to a diminution of its cropping capacity will probably be accepted by all as axiomatic. In some cases the reduction in crop is very evident as when the affected bushes die, say of a root disease, or when part of the frame is destroyed by wood rot or other stem disease. In others the loss in crop is not so evident; it may be difficult to compute, and is often of little economic importance. Amongst diseases of the latter type I would include 'Grey Blight' which normally attacks old leaf only, but does not cause general defoliation.

Although it is true that all disease results in loss of crop, the converse, that all reduction in crop is the result of disease, is obviously not true. We know that some bushes are inherently poor yielders and that no system of agricultural treatment will make them into good yielders. Similarly there are inherently good yielders, but adverse climatic or agricultural conditions may make them appear relatively poor yielders. The apparent poor yield resulting from such adverse conditions is of a temporary nature as improvement in the conditions results in an increase of yield. If that is not true, many are striving in vain.

A shepherd may know each individual of his flock but a tea planter does not and cannot know each tea bush in his fields. One has yet to hear of a tea planter reflecting on the past glories of a particular bush as he might of an old race horse. An old and weary looking dog may have won many prizes in his day but a decrepit looking bush, exhibiting no apparent disease symptom, is apt to be

regarded as having always been a 'dud.' Now if we had conclusive proof that a high-yielding bush did become permanently low yielding, yet exhibited no symptom of a known disease, we should have to regard the failure to put out flushing shoots as being itself a symptom of disease. In case my meaning may be obscure, I will briefly refer to a disease of plantains known as 'bunchy top' with which many of you are possibly acquainted. The bunchy top tree is readily distinguished from the normal healthy one by the fact that the former has its leaves all bunched together forming a rosette at the top of the stem. Such trees are unproductive and their root suckers display the same type of bunched growth. The bunching of the leaves is due to the failure of the leaf stalks to elongate normally. In other words the failure to grow normally is a symptom of bunchy top. The failure of a tea bush to grow normally would also be a disease symptom, though the change from normality would probably differ from that noted in plantains.

We have recently had good cause for suspicion that certain bushes in up-country districts have become, and others are becoming, permanently unproductive and that these conditions are more widely spread than is generally recognised. The staff at St. Coombs is sometimes criticised for refusing to offer opinion in public till such opinions are verified by experiment. Today I am refuting that criticism, or perhaps merely supplying the exception which proves the rule, because I am going to speak of suspicions and opinions not yet verified. Moreover, I prefer to view a new disease, or suspected disease, from its worst possible aspects until I know its capabilities to do damage. So if I make some rather depressing remarks I hope you will bear in mind that they are opinions, not verified fact, put forward for the purpose of discussion and to direct attention to a condition of sundry tea bushes which I consider to be diseased.

My first acquaintance with the disease was in September, 1935 when a tea bush was sent to the laboratories from the Kandapola district for examination. The bush appeared unthrifty, but no lesions, or dead areas, were visible on the surface of the roots, stems of leaves. In short no disease was apparent to account for the condition of the bush. A more thorough examination, however, disclosed the presence of small dead areas in the cortex close to the cambium. The outer cortex appeared quite healthy. Fig. 1 on Plate 2 shows the kind of symptom that was found. The root figured had an area of cortex cut away, and the centre of the cut is very close to, almost touching, the cambium. The dead areas can be seen as dark coloured spots. That specimen is of a rather advanced case. More usually the dead zones are very small and appear as small yellow or yellow-brown specks.

Figure 2 of Plate 2 is a micro-photograph of a root in which the disease was not so advanced as that illustrated in Fig. 1. The rather prominent dark spots are dead cells. Seen under the microscope they appear yellow-brown, not black as in the photograph. The tissue in which they occur is technically termed the *phloem*. It lies just outside the cambium, which is an actively growing tissue forming wood on one side and phloem on the other. The wood, particularly that just within the ring of cambium, forms the channels through which water and the raw food materials dissolved in it are passed from the root to the leaves, whereas the phloem is the tissue through which the elaborated food materials are moved from the leaves to other parts of the plant. A blockage of the wood vessels leads to a wilt, but a breakdown of the phloem leads to starvation. When a tree is 'ring-barked' a complete ring of phloem is removed and that stops all movement of food to the roots. Ultimately, the roots die of starvation and they cease to send water up to the leaves. Then the whole tree dies.

This short description of the function of the phloem indicates how important that tissue is and suggests that the presence of dead cells in that tissue must to some extent affect the transport of food materials within the plant. Because of this symptom (death in the phloem) this diseased condition has been termed *Phloem necrosis*.

In the field the distribution of the affected bushes is suggestive of a root disease. The diseased bushes tend to occur in patches, not so clearly defined as those caused by Poria, as all the bushes within the patch are not apparently affected. The different recognisable stages suggest a slow deterioration but deaths are very infrequent.

Soon after my first field examination of this disease I was requested to visit other estates in the same district for various reasons and was shown similar bushes. Root examinations disclosed the same symptoms — *Phloem necrosis*. After a certain amount of laboratory investigation and a good deal of discussion with the planters in that district, we came to the conclusion that the disease had been present for some considerable time though the condition had not been recognised as a disease. The bushes had been regarded merely as unproductive bushes of rather low jât character. On several estates for some years past, such bushes had been systematically cut out yet that type had not been eliminated. In fact some superintendents were of the opinion that there were as many then as previously, despite the removals. That observation strongly suggests a steady deterioration.

At that stage the main diagnostic character lay below ground — a *Phloem necrosis* in the roots. Above ground we had no clear-cut

PLATE 1

Fig. 1

Fig. 2

Fig. 1. The tea bush on the left is severely affected by *Phloem necrosis*; that on the right, slightly. The root sucker on the left is also affected.

Fig. 2. Tea bush affected by *Phloem necrosis.*

PLATE 2

Fig. 1

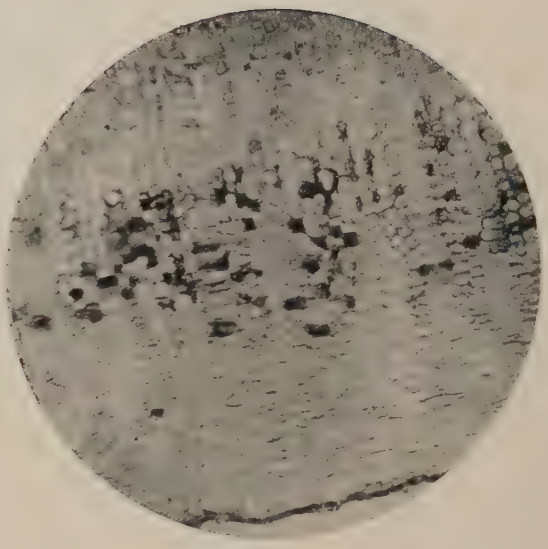

Fig. 2

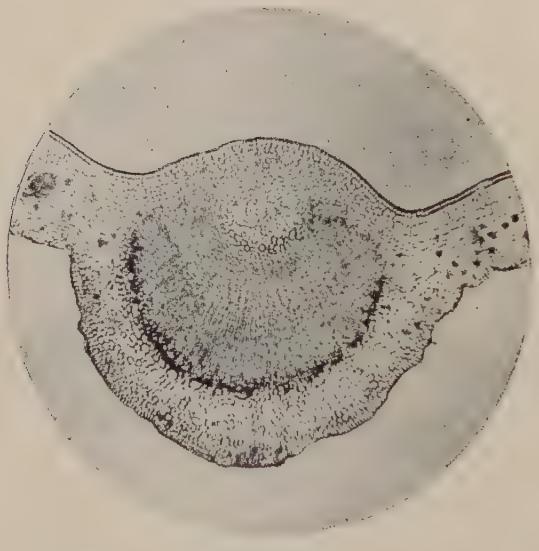

Fig. 3

Fig. 4

Fig. 1. Tea root showing necrotic areas near the cambium.

Fig. 2. Transverse section of a necrotic root showing dead cells × 43.

Fig. 3. Transverse section of mid-rib of a necrotic leaf showing necrotic zone × 32.

Fig. 4. Necrotic tea branch showing slight leaf curl.

symptom other than general unthriftiness and a tendency for some leaves to arch backwards. The bushes had what may be termed low jât characters with small leaf, often V-shaped, the mid-rib being the base of the V. Within the bush, branches with larger leaves could sometimes be found; and if such branches were truly representative of the original type of foliage, degeneration of type must have occurred.

The next advance was the discovery of unproductive bushes with markedly curled leaves. The curl was very similar to that which results from aphid attack on young leaves. See Figs. 1 and 2 of Plate 1. A necrosis was found in the petiole and midrib of these leaves and, in some cases, in all the small veins of the leaf also. This above-ground symptom offered a quicker means of identification and has helped us to recognise bushes in an earlier stage of attack. Plate 2 Fig. 4 shows a branch of a bush not yet in the advanced stage of the disease. The leaves are more or less normal in size but have a tendency to arch or curl backwards. Fig. 3 is a section through the midrib. The black semi-circle in the photo is necrotic tissue. Actually, this area is yellow or slightly brown in the specimen and that colour is largely masked by the green of the leaf when fresh.

The symptoms are not very constant. Some bushes have a marked necrosis in the roots and none in the petioles; others exhibit it markedly in the petioles but not in the roots. Some bushes have merely arched leaves and others exhibit a definite curl. These differences naturally raise the question whether we are dealing with one or more diseases. For the present I regard the disease as one, and the variation in symptoms the results of different reaction by the various varieties of tea.

I am demonstrating the symptoms of this disease tomorrow. I need say no more concerning them now, and will pass on to the cause of the disease.

I may as well tell you at once that we do not know for certain what causes the disease. The main possible causes can be grouped under the following heads:—

1. Visible parasites.
2. Environmental conditions, climate and soil.
3. Old age.
4. A virus, which I will define, rather incorrectly, as an invisible parasite.

1. Our first line of investigation was a search for a visible parasite. Frequent microscopic examinations and many attempts to

culture an organism from the diseased tissue have given negative results. This line of work is now being abandoned as profitless and we can say with a fair amount of confidence that the disease is not caused by a visible parasite.

2. The term 'environmental conditions' covers many factors which may be grouped as climate and soil. The incidence in the field does not suggest that climatic conditions are a main cause. It has been suggested to me that the drought of 1934 was an important factor. That may be so if the disease is transmitted by insects and if drought favours the development of that species. In that event drought takes a secondary position, one favourable to the propagation of the disease but not the cause of it. The symptoms are not, of course, drought symptoms pure and simple.

If soil conditions provide the primary cause, it cannot be a question of soil type, water table or general manuring; the evidence is strongly against those possibilities. A more likely guess is that the cause will be found amongst the minor elements such as manganese, boron, chromium, etc. Such elements in minute quantities are essential to plant growth; in the absence of one or other of them plants fail to make normal growth; if one is too abundant, its effect is apt to be toxic.

At various times we have transplanted necrotic bushes from different estates to St. Coombs. Of these 21 are still alive, and still necrotic. Diseased root suckers, which like the transplanted bushes had their roots freed from adhering soil, were planted in pots on St. Coombs, but are also still necrotic. Those plants are now growing in fresh soil and in a different climate, yet have made no improvement These experiments suggest that neither climate nor soil is the cause, otherwise some of the plants would have thrown off the symptom in their new growth. This evidence forms the basis of a statement I made earlier, viz. that affected bushes are permanently unproductive. I incline to the view that the disease is incurable.

3. Old age in plants is rather a big subject to include in a short paper like this. The hypothesis that this disease is little more than old age is one which appeals to several planters I know, but it is one which does not appeal to me at all. I can see no reason why a tree like tea should ever die If it could be protected against accident and against its many natural enemies, its pests and its diseases. A bush may die of drought, water-logging, lightning, root disease, termites, etc., but never of old age, *i.e.*, of senile decay as that term is applied to animals. I shall be prepared to discuss that subject with anyone interested tomorrow after my demonstration. In the meantime I would ask you to consider definitions (1) of death as

applied to trees, and (2) of a young plant such as tea, dadap grown from a cutting, potato grown from a tuber, and plantain grown from a root sucker. My reason for wanting those definitions is that we have successfully struck 5 single node cuttings from a necrotic bush. Each cutting consisted of one leaf and about an inch of stem. The bush has been dug out and burnt. I hesitate to say that it is dead, because it may be argued that the cuttings are not young plants but are as old as the tea bush from which they were taken; in fact they are the old tea bush. Two of those cuttings have been sacrificed to curiosity and their young roots were found to be severely necrotic. If the cuttings are young plants, necrosis cannot be a symptom of old age. If the cuttings are not young plants, then the original bush cannot be dead although uprooted and burnt. Hence I would like a definition of death as applied to a tree.

4. A virus is possibly not an organism, but it is so small that it cannot be seen even with a microscope and it is capable of increasing and multiplying like an organism, when situated in a suitable environment. There are many known virus diseases of plants but up to the present none has been described on tea. I am of the opinion, however, that this disease which we have called *Phloem necrosis* is caused by a virus. As yet I have no proof. If the disease is caused by a virus then it is probably transmitted by an insect about which we know nothing, not even its identity.

In the tropics we are well acquainted with insect transmitted diseases like Malaria. Virus diseases are transmitted similarly but the insects concerned are not mosquitoes as a rule. They are sucking insects like aphids, scales and bugs which suck the juice out of a plant much as a mosquito sucks blood. The malaria germ is, however, visible under a microscope but a virus which occurs in the juice of an infected plant is not.

I am basing my opinion that the cause is a virus on the symptoms, the necrosis and the mode of occurrence in the fields. Proof that the cause of the disease is a virus depends largely upon an ability to transmit the disease in certain ways to a healthy plant. One way, probably the surest, is by grafting diseased tissue to healthy. Tea is not one of the easiest of plants to graft even when dealing with healthy tissues, so the great majority of our attempts to affect union between the diseased and healthy tissues have failed. We have now, however, a few grafted plants but so far we have not observed any symptom in the healthy stock, but we cannot yet say that the result is negative *

In this connection there is a question which cannot be answered, namely how long must elapse before the first identifiable symptom becomes evident, *i.e.*, what is the incubation period? The develop-

* The disease has later been transmitted by grafting.—Ed.

ment of the disease in the field is very slow, a year seems to make little difference. Judging by that measure it is likely that considerable time must elapse between infection and the development of a visible symptom. That, however, is a guess, not an ascertained fact, so the incubation period remains obscure.

I regard the slow development of the disease to be one of its worst characteristics. At the last conference I pointed out the impossibility of eradicating a disease like Poria so long as infectious material was left in the ground. Poria may take 3 years to kill a bush and during the greater part of that time no above-ground symptom is apparent. By the time the bush is dead the fungus has passed on to the adjacent bushes. But that is an old story. *Phloem necrosis* takes longer to make a bush unproductive than Poria takes to kill it. Moreover if the disease is carried by a flying insect the spread of the disease will be much greater than what we know to be the case with Poria, which travels underground.

To illustrate my point I should like to recount a little phytopathological history. There is a disease of peach in the United States which goes by the name of Phony peach. The cause is now known to be a virus, but the way in which it is transmitted in nature is still unknown. Transmission can be carried out artificially by root grafts only and 18 months elapse between infection and development of the first identifiable symptom. The word "phony' is defined as "bogus, counterfeit, false." The affected trees are dwarfed. The disease does not kill the attacked tree, but roots from such trees have never failed to communicate the disease to normal trees in root grafting experiments. The longevity of phony trees is recognised to constitute a serious problem in the eradication of the disease.

The phony condition was first recorded in Georgia before 1890. Phony trees began to be more prevalent about 1900, but not until 1915 was the situation regarded as serious and the U. S. Department of Agriculture's aid requested. At that time few of the growers believed it to be a disease, but considered it in the category of a sport, a degeneration of stock, (*i.e.*, old age) or an overdose of nitrogenous fertiliser. The great havoc it was destined to work was not foreseen. About 1928 the disease was proved to be contagious and control measures became a federal activity in 1929. By 1936 the disease was known in 15 States located in the S. E. quarter of the United States.

One of the problems of effective control is the reinfection of orchards from nearby diseased, abandoned and escaped peach trees, the removal of which was outside the scope of regular federal activities and beyond the means of available regular funds. From the Emergency Relief Appropriation was allotted a sum of 840,000

dollars for the removal of such trees by a force of 2,000 men. In four months 2 million abandoned and $3\frac{1}{2}$ million escaped peach trees were removed. These figures which refer only to the expenditure outside the commercial orchards, will give you some idea of what this disease has cost the United States and the peach industry.

I have mentioned the phony disease of peach to show what extensive damage a disease which does not kill rapidly may do. I am not suggesting that *Phloem necrosis* of tea will follow a similar course, but it is up to us to see that it doesn't. To this end I ask your active co-operation. I am of the opinion that the disease is spreading. We now know it in the Kandapola, Bandarawela, Nuwara Eliya, Hewaheta, Dimbula and the Agras districts, and it possibly occurs on many estates not yet recorded. It is quite impossible for an officer of the Institute to visit every estate to search for the disease If, however, superintendents when on their rounds would keep a lookout for this disease and send specimens of suspected cases to the laboratory for examination, we should be able in a relatively short time to acquire a fairly accurate knowledge of the present distribution of the disease. With that information acquired, it would be possible to formulate reliable conclusions concerning its rate of spread and the conditions which favour it.

Since becoming acquainted with the disease a watch has been kept for its occurrence on St. Coombs. We found it for the first time last year and early stages are now known to occur in several fields. Our neighbours, however, have more bushes exhibiting advanced stages and I have no doubt that the disease has been present in Dimbula for some years, but unrecognised. The disease has probably been present on St. Coombs for some time yet remained unnoticed, but I think the fact that the majority of the affected bushes show only the early symptoms of the disease may be interpreted as indicating that the disease has arrived fairly recently. We know nothing about the way the disease is transmitted and very little about its rate of spread.

In the course of an experiment we examined 639 bushes and diagnosed 266 of them, *i.e.*, 42 per cent, to be affected by *Phloem necrosis*. The affected bushes were by no means all non-productive; in fact many of them would be passed by a planter as healthy. Eight months later the same bushes were again examined when the number diagnosed as diseased had risen to 334 or 52 per cent. This represents an increase of 10 per cent in 8 months. The plots as a whole and the bushes individually did not look worse at the second examination. I do not suggest that these figures represent the general rate of spread. They are the only figures we have and they relate only to a small area of tea in a heavily infected area.

There remains the question what should be done about it. My recommendation at present is that unproductive bushes should be removed. That is a sound economic proposition independent of any question of disease. I realise that by making the criterion unproductivity for the time being, the Institute is open to criticism that it is avoiding its responsibility for dealing with the disease as a disease. To that criticism I woud reply that if unproductive bushes are removed they will include amongst them the worst cases of *Phloem necrosis*. I admit that that treatment alone would never stamp out the disease if the opinions I have expressed are founded on fact. Let us assume for the moment that my opinions have been proved to be true by experiment and observation, and then consider what steps should be taken to eradicate the disease. The most important would be the removal of every bush as soon as it showed the first symptom of the disease no matter whether the bush cropped well or not. It would be of little use for one estate to remove its infected bushes if its neighbours did not do the same. Treatment may, therefore, have to be compulsory, and it would have to be very thorough. Before the Industry would consider taking such a step it would have to be convinced that such measures are essential. It would require facts and proofs, not opinion such as I have expressed today. So perhaps you will agree that the recommendation to remove unproductive bushes is as far as we can go at the moment. Later action will depend upon the results of further investigation.

I therefore ask your active co-operation in an effort to acquire a more intimate knowledge of this disease. I have viewed it from some of its worst possible aspects. Possibly, some of my views are wrong and investigations may prove them so. Until that is done I consider that *Phloem necrosis* should be regarded as a disease capable of causing very great damage.

In conclusion, I wish to thank the many planters, particularly those of the Kandapola district, for their active co-operation and the ready help they have given me to acquire what little knowledge we have of this disease. I would also express my appreciation of the work put in by my assistant, Mr. C. A. Loos. In one respect, at least, he has proved a great time saver in that he can detect the presence of necrotic zones in the petioles of diseased leaves without the aid of a microscope — a thing I cannot do myself.

DISCUSSION

Mr. F. R. Francillon first expressed appreciation of the interesting address Dr. Gadd had given. He agreed that the spread of the disease was very slow as he had known of that condition of

tea, now called *Phloem necrosis*, for the last 20 years. During that time there had not apparently been any great increase of it, and the field in question had in 1938 yielded 1,080 lbs. of made tea per acre which of course is a very good yield. Was it not possible Dr. Gadd was being over pessimistic?

Mr. C. M. Durbin said that coming from the Kandapola area he had considerable practical experience of the trouble which Dr. Gadd has described, and that experience suggested that the disease was a very serious menace to the Industry. The disease had probably been present in the Kandapola area for the last 10 or 15 years and they (the planters) had attributed it to a deterioration of jât as a consequence of high elevation. Now the disease had reached a much worse stage and it was not only killing individual bushes but was affecting the yield of estates.

He had been very much impressed by the remarks of Sir John Russell that morning concerning minor elements and the part they played in causing disease. They were accustomed to applying nitrogen, phosphoric acid and potash in manure mixtures but they had no information concerning the requirements of tea as regards minor elements. While he was in London recently he saw a report on the analyses of healthy and necrotic tea specimens sent home by the Tea Research Institute and that report seemed to indicate the possibility of soil conditions being the cause of the disease. So far as he remembered, that report suggested two possibilities, (1) a deficiency of manganese or (2) an excess of chromium. In view of these suggestions he hoped that Dr. Gadd would not reject soil conditions as a possible cause until the effects of minor elements have been determined.

Dr. Gadd had been rather severe on the suggestion that the disease was a result of old age, and in view of what had been said it seemed that the hypothesis would have to be abandoned. Still he thought there was the possibility that bushes 50 or 60 years of age, maltreated as they were, particularly at pruning time, might be more susceptible to disease than young plants would be. At present it seemed that only old bushes were attacked. That appeared to him to be a very important point because young supplies were being put out in the necrotic areas. The planting of supplies had been going on for the last 10 years and so far no necrosis had been found in the young plants. If necrosis should be found later in those young plants, the problem would become much more serious and he hoped in that case that it would not be long before he could retire. Although he admitted the possibility that the disease might attack young tea he sincerely hoped that it would not.

Finally, he said that he would like to tell Dr. Gadd that the planters in the Kandapola district were well aware of and much appreciated his great interest in this problem, which they regarded as of serious importance, and wished to thank him for all he had done to help them. He also expressed thanks to Mr. Loos who had worked extremely hard upon that problem.

Dr. Gadd in reply said that he felt sure that Mr. Francillon did not regard the high yield of the field he had mentioned to be a result of *Phloem necrosis*. He had been told by superintendents of surprisingly large numbers of diseased bushes which had been removed from fields without depressing the yields. Such statements illustrated to what small extent necrotic bushes contributed to the yield of the fields. Consequently he thought that Mr. Francillon would find that his excellent yield would not be materially reduced if he (Mr. Francillon) removed the severely diseased bushes.

With regard to Mr. Durbin's remarks concerning minor elements he stated that the spectrographic analysis, which had been very kindly and expertly done for the Institute at Home, had limited the field of exploration very considerably. He assured Mr. Durbin that that aspect of the problem would not be lost sight of. In fact, while Mr. Durbin was on leave the Institute used a part of his estate for that very purpose. The minor element experimented with was boron but the boron treated plots showed after 8 months the same increase of the disease as did the control plots.

Mr. Durbin had referred to chromium as a possible cause of the disease. Dr. Gadd stated that chromium in excess was well-known to be toxic to plants so he had enquired of the chemist who had made the spectrographic analysis what quantities were involved in the tea samples. At considerable trouble the chemist had determined that the healthy tea contained about 1 part per million while the diseased samples contained about 2 parts per million. He was rather puzzled at the moment as to how he could increase the chromium content of healthy tea from 1 part to 2 parts per million in order to ascertain whether thereby the disease symptoms could be induced.

Concerning the age of affected tea plants, he said that he felt so confident that old age was not an important factor that he was working mainly with seedlings and young plants. Only last week he had examined two branches taken from a supply not more than 4 years old which had been sent to him suspected to be affected. The branches showed unmistakable external symptoms of the disease but as he had failed to find any definite internal necrotic areas he regarded his examination to be negative for the time being. He felt

sure that in a few weeks' time he would have little difficulty in finding necrotic areas in that plant. In that event it would be evident that young plants are not immune. He had dealt rather harshly with the old age hypothesis because he did not want them (the planters) to believe that, old age being the cause, the trouble would be avoided merely by pulling out the old tea bushes. His fear was that young tea would acquire the disease as readily as old bushes. He regarded that as a very serious character of the disease.

TORTRIX CONTROL

C. B. REDMAN KING, M.A.

Eleven years ago, as most of you will remember, Tea Tortrix was proclaimed a declared pest by notification, at the instance of a body of planters through the Planters' Association.

The regulations made were as follows:—

1. All egg-masses of Tea Tortrix on tea must be collected and burned within 24 hours of collection.
2. All larvae and pupae of Tea Tortrix on tea must be destroyed.
3. Records of collection of Tea Tortrix by weight or by number of leaves made upon all estates over 10 acres in extent shall be sent to the Department of Agriculture at such intervals not exceeding 3 months as may be required by the Department of Agriculture.

The usual practice has been to carry out collections during plucking rounds, an easy and convenient method fitting in with estate routine, but not very sound. Inquiry into the life-history, and especially into the seasonal history of the Tortrix was initiated to see if it were possible to improve the method already adopted and recognised. This led to the discovery of 5 regular generations of Tortrix a year, and of a periodic rise and fall in the population in the same space of time. With this information, a scheme was worked out which appeared to be more efficient than the one then in vogue, and it was made the subject of a paper presented at the last conference, two years ago.

But while doing so, the situation even then was changing; and the cause was a parasite introduced from Java.

Seven years ago I had come to the conclusion by a study of available data that there might exist in Java some parasite, not at that time in Ceylon, more effective than any of those indigenous to this Island; which, indeed, were all pretty poor from our point of view. Correspondence on the subject however, came to nought and it was not until 1935 that we were able to get our first consignment of parasites from Java, after the Chairman and Director had established personal touch with the authorities in that country.

In preparation for the reception of the insects, we had chosen the most suitable position on the estate for liberation of some of the parasites, and had prepared a large number of Tortrix-affected branches in cages in the laboratory; in addition to this, a field cage was built round eight tea bushes which had been liberally supplied with Tortrix caterpillars.

As far as breeding was concerned, the parasites kept under observation were a failure, both in the laboratory and in the field cage. The place where the remainder were liberated had but a mild Tortrix attack and after several months of waiting and watching there appeared to be no result; in fact, one cluster of cocoons only was found, all of which were male. It was therefore resolved to try once more, and a further batch of parasites was received in September, 1936, most of which perished in transit. The survivors were released on St. Coombs on a Tortrix-infected area.

It was not till December, 1936, that it was found that the first lot of parasites had, in fact, survived, and were now multiplying at a fair rate. After some further observations it was decided to make a survey to estimate the extent of the region now covered by the parasites. This was accordingly done in February, 1937, just 2 years ago, and it was found that they were spread over about 50 acres round the point of liberation. A similar survey with regard to the second importation was virtually negative.

However, as the year wore on, the parasites increased their spread over St. Coombs, as well as on Cairness next door, and plans were made to start fresh centres of activity. For this purpose it was necessary to discover Tortrix concentrations of sufficient density to give the parasites a good start. As the result of enquiry, small parcels of about 100 or so males and females were liberated on Diyagama in Dimbula, and on Bunyan and Queensland in Maskeliya, in October, 1937, 16 months ago. In December of the same year, parasites were put out on Edinburgh and West Holyrood estates. In 1938, Doragalla in Pussellawa, was treated in March; Roeberry

(Madulsima) in August; and Cocogalla (Madulsima) and Theresia (Dickoya) in October. That is the extent to which we started fresh foci, which were of course necessarily conditioned by the presence of sufficient Tortrix caterpillars.

I will not weary you with a list of estates on which *Macrocentrus* has now been found, but I will just mention the number of estates on which it has been discovered in various districts:—

Dimbula	...	12
Maskeliya	...	11
Pussellawa	...	3
Dolosbage	...	1
Pundaluoya	...	1
Kotamale	...	1

This is a crude picture of the situation as it is at present. We are only able to compile such a list from the material sent by estates, most of which on enquiry, reply that they have no Tortrix.

We begin to divine something of what has taken place, however, when we take into account the position of certain estates on which the parasites have been found. Take for instance Dunsinane in Pundaluoya. It is ringed about by high mountains, except towards the north. It is difficult to resist the conclusion that the little wasps flew from Pussellawa, some 6 or 7 miles from the nearest infested estate in that direction. It is highly probable that they were to be found on intervening estates at the same time also. Again, they have been found on Pen-y-lan estate, about 10 miles west of Doragalla, the nearest place on which the parasites were liberated The intervening country is, one would think, a difficult one for such small insects to traverse in so short a time, intersected as it is with mountains and valleys. I think it fair to assume that *Macrocentrus* could also have been found on estates between the two.

At the present moment we have more information about the Maskeliya Valley than any other district. Parasites were liberated here in October, 1937, and within a year were found in some numbers from Fairlawn at one end to Hapugastenne at the other, and I think it may fairly be said that the parasite is now well established over there.

So much about its distribution for the present. Let us turn for a moment to the insect itself and watch it at work.

Those of you who have seen it will remember that it looks something like a smallish, slender mosquito. The sexes are easily distinguished, for the females are provided with a long straight ovipositor lacking in the male, which sticks out behind, and which is about as long as the body. When she has found a victim (the males having nothing to do with this part of the business) she walks up and down on the outside of the curled leaf in which the caterpillar is lying. Having worked herself up into a sort of frenzy of excitement, she raises her abdomen up and directs the ovipositor between her feet, the intention being to drive it through the leaf into the caterpillar, in which the egg is laid. I have watched this process many times, and I have been struck with the fact that the parasite is an extraordinarily bad shot, repeatedly missing the intended victim. I was particularly impressed by the poor quality of the marksmanship, since the writings of Fabre and others always stressed the deadly accuracy of this class of parasite, relating in great detail how they would select particular segments or spots to lay an egg, or particular nerve ganglia to sting and paralyse, but not to kill.

Well, that is another illusion gone. But, when all is said and done, hit and miss though its methods may be, the parasite is unquestionably extremely efficient.

From the egg stage onwards for some time, the development is shrouded in mystery. All we know is — that a number of grubs, up to about 30 or so line themselves up inside, along the intestine, and feed at the expense of the caterpillar. The latter does not *appear* to be incommoded but carries on as usual, casting its skin at intervals until full grown.

The development of the grubs within, until completed, occupies about a month, and they then pierce the skin of the caterpillar and spin cocoons in which pupation occurs. At this stage, nothing is to be seen of the caterpillar except its head. Now this is the stage which can be recognised in the field — a bundle of brown cocoons, like minute cigars inside the clustered leaf where a caterpillar is wont to be found. In about three weeks after the exit from the caterpillar, the adult insects emerge and the cycle begins once more.

The parasite was named last year by the British Museum as *Macrocentrus homonae*, the second name referring to Tea Tortrix whose official name is *Homona coffearea*. Up till the time of its introduction into Ceylon, 21 different species of parasites were already known but *Macrocentrus* is far better than all of them put together.

After its introduction, it started very slowly, but as time went on it seems to have gathered both speed and momentum. It took fifteen months to spread over 50 acres; by the end of another year it

covered about 1,000 acres; and after a further period of twelve months, bringing it to the present time, it now occupies an area of at least 600 square miles. Its efficiency may be judged from the fact that the rate of parasitism recorded from various places usually varies between 50 and 100 per cent, compared with maxima of 5 per cent of other parasites in pre-*Macrocentrus* days.

The continuous suspicion with which a research worker regards the progress of events tempts one to ask the question: "Where is the snag? Is it going to keep going at the present rate or will it fade away in the future?" We cannot answer these questions at present, but being an imported insect it may perhaps modify its behaviour, owing to differences in environment compared with Java. It has in fact shown tendencies towards modification since its arrival. I have already referred to two of them — one is the increasing rate of development in the open; the other is its ability to breed under artificial conditions which it appeared to be unable to do for a couple of years or so. Both these tendencies have been in the right direction, demonstrating a favourable response to the new environment and so at present the future may be regarded with hope.

There is however a further factor that I must not forget to mention, and that is, the appearance of natural enemies. Just as caterpillars and other pests are mostly kept in check by parasites, so also the latter may themselves be controlled by parasites, or as we call them, hyperparasites. In the last three years we have found four different insects which could be put into this category, three of which might be regarded as more or less accidental. The fourth, however, is completely hyperparasitic. It is found in Java as well as here, but its occurrence on *Macrocentrus* has been so far very rare, and I think that it may continue to be of little importance. However, there remains the possibility of others turning up which may prove to be of more significance.

I think we may assume that *Macrocentrus* will become part of the permanent environment of Tortrix. Now this pest in the past has shown periods of great activity followed by periods of eclipse. We do not know how regular these are, or how long they may be taken to be. For the last 8 or 9 years Tortrix has been on the down grade and, apart from localised areas of small extent, has not given much trouble of late. It may not be long before the opposite tendency sets in, when the great majority of eggs that hatch reach maturity, which at present they don't. If this revival comes suddenly, it may be followed by a regular Tortrix attack, as you have known it before. The population of the parasite is dependent on that of its host, but the latter always retains the initiative, and

therefore it can get away fast, and leave the parasite as it were standing. But with increasing population the parasite also increases apparently at a greater rate, so that presently the pest is caught up and held Broadly speaking, this means that when conditions are favourable for an increase in Tortrix there will be a definite attack, but it is likely to be of lesser degree and of shorter duration than formerly, and it is probable that the tea in the early part of the year will escape much damage. In the near future I do not think it will be necessary to take any artificial counter measures, since control is fully automatic, and better than anything *you* can do.

Macrocentrus has given plenty of evidence of its ability to spread, so that fresh liberations may perhaps not be necessary in the future. It will be realised, after what I have said, that it attacks the caterpillar stage, and so maintains itself in the field. We have had many applications for parasites from various estates without reference to the suitability of conditions on each estate, *i.e.*, the presence of caterpillars. Liberations can only be justified where there is an attack in progress, and the parasite is absent. I would suggest therefore, that any estate which would like assistance in this way should send in a number of caterpillars and leaf in a wooden box *with* their application, so that examination can be made as to the presence or absence of *Macrocentrus*.

That, then, is the position of affairs as it stands at present. I have outlined the control measures as adopted up to now, the history of the spread of this parasite, and its mode of attack. If I add that it seems to know no other hosts except Tortrix, and that even where Tortrix is very difficult to find, half of them may be parasitised by *Macrocentrus*, we have the story more or less complete as we know it at the present time.

In conclusion, we consider the situation to be sufficiently favourable to approach Government with a view to having Tea Tortrix removed from the Pest Ordinance, and if this comes to pass you will be relieved of the obligation to collect and destroy all egg-masses, larvae and pupae, and to send in every quarter, records of such collections.

The Chairman then invited Sir John Russell to review the proceedings of the Conference.

REVIEW OF THE CONFERENCE PROCEEDINGS

SIR JOHN RUSSELL

I hesitate very much to detain you longer, but the proceedings have been so extremely interesting that I have had great pleasure in noting certain points and as the Chairman has invited me to do so I present them to you.

First of all, I was very much impressed with the insistence both by the Chairman and the Director this morning that the staff of the Institute should be kept in close touch with the Industry. I am perfectly certain that that is the only way in which the Institute can ensure and deserve success. Unless this is done the tendency will be for the different branches to get into watertight compartments. It was particularly interesting to hear the reference made both by the Chairman and the Director to the advisory work and special conferences and the discussion that arose on that point. I hope it will be found practicable to keep every senior member of the staff in close touch with the problems of the Industry.

The Director's suggestion that it may become necessary to abandon unduly steep and exhausted land and intensify production on more suitable areas is a wise one, and one which has been adopted elsewhere and proved to be an economic solution to difficult problems that arise when the possibilities of overproduction or restriction have to be considered.

Dr. Eden, I thought, tackled the question of cultivation on the right lines in relation, first of all, to weeds, and then to root development. That raised the question of what weeds should be kept, and I think he was on sound lines in suggesting the advisability of selective weeding, getting rid of grasses, and studying other weeds to see which of them would turn out best as soil conservers and, perhaps, also add organic matter to the soil.

The discussion on pruning mixtures was extraordinarily interesting because it brings out the point whether you should manure for the immediate crop or the ultimate health of the tree. It is a question that does not admit of any general answer. It has to be settled for each particular industry. Of course in a way it is settling itself in the experiments that are going on in the Institute because those experiments will continue, and you will sooner or later see whether

the methods now used will be finally good for the plant in giving the additional wood or growth that seems to be necessary, or whether these will be at the cost of the ultimate disadvantage of the bush.

That, of course, is one of the great gains of continuing experiments. You work on a five-year programme. That is an advantage, but field experiments will have to continue very much longer. Our field experiments at Rothamsted have continued for eighty-five, and some for ninety-five, years, and they get better as they get older. There is no question with us of what you mean by old age, and the older the experiments are the fuller they are of information. You can get from a long-continued experiment information which you cannot obtain in any other way. I hope, whatever financial arrangements may be made for the Institute, it will always be found possible to maintain selected field experiments as long-continuing things, especially experiments on manuring and cultivation where the immediate yield of the leaf is not the final criterion. The final criterion is: Can the plant keep it up? and that you can only tell by carrying on the experiments.

Dr. Tubbs has started a really splendid piece of work on the question of the selection of bushes. I can only hope it will prove as successful as similar work on fruit trees has been in England. It is, of course, notorious that bushes do differ from one another, and selection for yield and quality offers an excellent means of improving the output of crop and financial values. It is just the same labour to look after a poor bush as to look after a good one. Selection is a very good way of getting at the best material to work on. It should be possible also to select for disease resistance when the problem arises.

As regards Dr. Tubbs' reference to work in Russia on tannin content, it so happens that a member of our Rothamsted staff has been working with the Russians in Georgia on their tea problems. I was there only eighteen months ago, looking into this question of yields. You need not be afraid of Georgian tea. It has not anything like the same quality as your tea, and you need never fear it.

The Director's review of manufacturing conditions was, as one would expect, a masterly survey, and I was pleased to see the influence of his early upbringings at the Lister Institute when he emphasised the need for factory hygiene.

Mr. Finley's mass of detail shows how many engineering problems there are still unsolved, and how much remains for the Institute to do in an untouched field.

Dr. Gadd's paper also interested me very much. We are working at Rothamsted on virus diseases. They are very difficult and obscure, and at the present time there is no cure for them. There is a possibility as in the case of other crops of finding resistant varieties, but that is a long and difficult business. One can only say of this virus disease that it is different in many ways from other virus diseases we know. There still remains the possibility that it is one of the obscure deficiency diseases as was suggested by one of the speakers — possibly a manganese or some other deficiency. We are only at the beginning of deficiency diseases and it is possible that some substance that has hitherto not been observed in other cases is needed for it. It seems quite clear that there is a lot of work to be done here and it is very fortunate that the Institute is tackling the problem now before it becomes too serious.

Mr. King's paper showed how it is possible to solve a difficult problem. It looks from what he says that the problem of Tortrix is now well in hand. One can only hope that the success achieved there may be achieved also in regard to this other and at present very obscure disease

The papers and the whole of the group discussions struck me as being peculiarly good, showing that the Institute has got very well down to the problems of the Industry, and also that the representatives of the Industry themselves, the planters, have a very good hold on their problems. They know what it is they want and are, therefore, able to help the Institute to help them.

Once more I thank you for giving me the opportunity of listening to this interesting discussion, and express the hope that the Institute may prosper and be able to give you the help that you need in your daily work.

The Chairman expressed the great indebtedness of the Institute and of those present to Sir John Russell for his presence at the Conference and for the active part he had taken in the proceedings. He also thanked those who had joined in the discussions.

The Conference was then declared closed.

NOTE ON THE CHLORINE CONTENT OF TEA LEAVES BEFORE AND AFTER MANURING WITH MURIATE OF POTASH*

P. A. KEILLER, F.I.C., F.C.S.

The following are the percentages of chlorine found in the dry leaf (flush) of tea bushes manured with muriate of potash:—

	No. of Days	Chlorine per cent	Rainfall ins.	No. of Days	Chlorine per cent	Rainfall ins.
Before Manuring	18	0.176				
	7		0.86			
	3		0.04			
	2		1.10			
	1	0.200				
After Manuring	1	0.200		25	0.206	
	2	0.203		26	0.210	
	3	0.215		27	0.205	0.05
	4	0.212		28	0.206	
	5	0.194		29	0.206	
	6	0.206		30	0.212	
	7	0.181		31	0.219	
	8	0.174	0.06	32		
	9	0.176	0.34	33		
	10	0.181		34		
	11	0.203		35		0.18
	12	0.173		36	0.160	0.04
	13	0.177		37		0.16
	14	0.169		38		0.91
	15	0.182		39	0.199	0.04
	16	0.184		40		
	17	0.181		41		
	18	0.183	1.59	42	1.190	0.08
	19	0.189	1.25	43		
	20	0.188		44		
	21	0.175		45		
	22	0.176		46		
	23	0.186		47		
	24	0.192		48	0.182	

Representative samples were drawn from the 4 quarters of the plot 18 days before manuring, and these showed the following percentages: 0.168, 0 158, 0.173 and 0.205 (mean, 0.176). Subsequent samples were taken from the mixed flush from the whole plot.

*The Institute does not necessarily endorse the views expressed in papers contributed by persons other than members of the Staff.

The manure application has altered the composition of the leaf only very slightly, if at all, and it appears from the above figures that the quality of made tea is unlikely to be affected by manuring with muriate rather than sulphate of potash.

NOTE ON THE ANALYSIS OF LEAVES FROM TEA BUSHES AFFECTED BY "WITCHES BROOM"*

P. A. KEILLER, F.I.C., F.C.S.

The following is a brief summary of the reports received on leaf samples from two estates, A and B, where "Witches Broom" occurs. The leaves were examined spectroscopically by Dr. Judd Lewis, Analytical and Consulting Chemist, London, who has made a speciality of this work.

ESTATE A

Arranging the samples in the order of severity of attack coincided with the order of their chromium content.

Two out of the four samples of healthy leaf showed no chromium, while the other two showed a "minute trace" and a "very faint trace." All the affected leaves (5 samples) showed more chromium, the amount increasing with the severity of the attack. The worst bush, on which the leaves were nearly white, showed $2\frac{1}{2}$ times as much chromium as the best of the affected bushes.

Calcium was lower and the alkali metals (K, Na and Rb) higher in the affected leaves.

ESTATE B

Chromium occurred irregularly in this series, and was present in three out of the four samples of healthy leaves and in all the six samples from affected bushes. The quantities were much less than in A (about one-tenth).

The worst bush showed an abnormal amount of barium, with remarkably little potassium and sodium. Barium occurred in all the samples but not in any regular sequence. It also occurred in all samples from estate A, but in much less quantity.

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* The Institute does not necessarily endorse the views expressed in papers contributed by persons other than members of the Staff.

The indications from this summary are that Witches Broom is more likely to be a poisoning effect than a deficiency disease, and is not necessarily always due to the same cause although the outward symptoms may be similar.

The writer has found that chromium administered either as potassium chromate or as chrome alum causes the death of tea bushes, but even with large doses (1 cwt. per acre of either salt) the effect is slow and several months elapse before death takes place. The chromium probably becomes largely insoluble after application.

Chromium poisoning of citrus trees has been reported from South Africa, but so far as the writer is aware no case of barium poisoning is recorded.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 31-3-39

Minutes of a meeting of the Board of the Tea Research Institute of Ceylon held at the Grand Oriental Hotel, Colombo, on Friday, 31st March, 1939.

Present.—Mr. James Forbes (Chairman), the Hon'ble the Financial Secretary (H. J. Huxham), the Director of Agriculture (Mr. E. Rodrigo), the Chairman, Planters' Association of Ceylon (Mr. R. C. Scott), the Chairman, Ceylon Estates Proprietary Association (Mr. R. J. Hartley), Messrs. I. L. Cameron, J. D. Hoare, J. C. Kelly, S. F. H. Perera, Gordon Pyper and Dr. R. V. Norris (Director and Secretary), and by invitation Dr. C. H. Gadd.

Major J. W. Oldfield and Mr. T. B. Panabokke had both intimated their inability to be present.

1. Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board held on 22nd December, 1938, were confirmed.

3. MEMBERSHIP OF THE BOARD AND COMMITTEES

Board (a) Reported that Mr. Gordon Pyper had been nominated by the Planters' Association of Ceylon to act as a member of the Board during the absence of Mr. R. G. Coombe (Letter dated 31st January, 1939, from the Secretary, Planters' Association of Ceylon).

(b) Reported that Mr. I. L. Cameron whose nomination as a member of the Board expired on the 27th January, 1939, had been renominated by the Ceylon Estates Proprietary Association for a further period of 3 years as from that date. (Letter dated 3rd March, 1939, from the Secretary, Ceylon Estates Proprietary Association).

The Chairman congratulated Mr. I. L. Cameron on his renewed nomination and welcomed Mr. Pyper to the Board.

Experimental Sub-Committee.—Mr. J. D. Hoare was invited to act on the Experimental Sub-Committee during the absence of Mr. R. G. Coombe on leave.

4. FINANCE

(a) *Audited Accounts for 1938 and Auditors' Reports.*—The Chairman said the audited accounts for 1938, of which members had copies, had been considered by the Finance Sub-Committee together with the Auditors' Reports. The reports were of a very satisfactory nature indeed and reflected credit on the Director, Superintendent and the office staff. It was gratifying to note that the various changes previously recommended by the auditors in the estate accounting methods were all working smoothly and had received favourable comment by the auditors.

The question of insurance cover which was referred to by the auditors had been considered by the Finance Sub-Committee who were satisfied that the present cover was adequate.

The Audited Accounts for 1938 and the Auditors' Reports thereon were approved by the Board.

(b) *Institute's Accounts for January and February, 1939.*—These were approved without comment.

5. ST. COOMBS ESTATE

(a) Visiting Agent's Report dated 16th December, 1938.

(b) Minutes of the 40th Meeting of the Experimental and Estate Sub-Committee held on 28th January, 1939.

The Chairman suggested these be considered together.

Desmodium gyrans.—In reply to a question Dr. Gadd said there was nothing to add in regard to the position of this plant in relation to eelworm.

Clearings.—The Chairman referred to the failure of the North-East Monsoon and the severe drought experienced in Dimbula which had seriously prejudiced the success of the clearing.

In reply to Mr. Cameron and to Mr. Scott, the latter of whom favoured the use of basket plants, the Director said that seed-at-stake, 4 seeds to the hole, had been used in order to provide a basis for selection. This consideration had rendered the use of basket plants impracticable.

Mr. Perera expressed doubt as to the advisability of using Vigna on the clearings and the Chairman said further details would be obtained before this was done.

Mr. Cameron asked if lime-washing was to be recommended for dealing with lichens and moss. Dr. Gadd replied that he thought this practice was of little use and that removal of lichen and moss was best done by hand. Mr. Scott concurred.

In reply to Mr. Hoare who asked if *Tephrosia vogelii* was to be used on the clearing, the Chairman pointed out that the Experimental Sub-Committee had recommended the use of Crotalarias and *Desmodium gyrans.*

(c) *Sanitary Inspector's Report, St. Coombs Estate.*—The Chairman reported that the inspection was carried out on 15th February and the report was satisfactory. Items requiring attention were of a minor character and would mostly be carried out this year, any matter outstanding being provided for in 1940 estimates.

6. TEA RESEARCH INSTITUTE CONFERENCE

The Chairman said that the recent conference which had been well attended was very successful and read the following extract from a letter he had addressed to the Director on the subject:—

> "I write to convey to you and your staff an expression of my appreciation and admiration for the excellence of all the papers and arrangements at the recent conference. I think the organisation from your end was beyond all praise and I will be glad if you will convey my feelings in the matter as above to all those concerned. I think everyone is agreed that it was the best and most interesting conference we have so far held."

The Board endorsed the opinion expressed by the Chairman.

Arising from the Director's address, the CHAIRMAN said various suggestions had been made in regard to additional conferences or meetings between the Institute's Staff and representatives of District Planters' Associations in order to maintain contact in the intervals between the main conferences. A letter on the subject had been received from the Planters' Association of Ceylon and a Memorandum drawn up by the Director had been circulated to members.

The Chairman,
Tea Research Institute of Ceylon,
Thornfield, Agrapatna.

SUB-CONFERENCES

Dear Sir,

My Chairman informs me that at the Tea Research Institute Conference on the 13th instant it was suggested that each District Planters' Association should nominate two members to represent their districts, who could attend "sub-conferences" in the event of any pest or disease of tea being prevalent in their districts. For instance at the moment *Phloem necrosis* seems to be prevalent in the Kandapola District and it is thought that a sub-conference between representatives of the Nuwara Eliya District Planters' Association and an officer or officers of the Tea Research Institute might be beneficial to all concerned.

Before bringing the suggestion to the notice of this Association's General Committee, the Chairman would like to know as soon as possible if the Board of Management of the Tea Research Institute approve of this suggestion.

A further suggestion is that a small Sub-Committee of representatives of up, low and mid-country, Ceylon Estates Proprietary Association, and Tea Research Institute with power to co-opt others should be formed, thus enabling matters of interest to be discussed as and when advisable and thus maintain interest during the two-year intervals between conferences.

Yours faithfully,

(Sgd.) ARTHUR W. L. TURNER,
Secretary.

Victoria Commemoration Building,
P. O. Box No. 42, Kandy.
22nd February, 1938.

CONFERENCES

Memo

(1). In my address at the recent conference I invited opinion on the following suggestions:—

(a) That periodical meetings might be held at St. Coombs as occasion arose between the Scientific Staff and representatives nominated by the Planters' Association and the various District Associations, the object being to secure the closest liaison between the Institute and Districts

(b) The holding of occasional small conferences to discuss in some detail any special problems of immediate topical interest.

(c) That two days per month be set aside for visitors to St. Coombs instead of one at present.

In regard to (a) there seemed to be general agreement that such arrangements would serve a useful purpose. It was suggested each district might nominate two representatives for the purpose, but not necessarily the same men on each occasion, the choice of persons being determined by the nature of the problem to be discussed.

In regard to (b) it was pointed out that if attendance at proposed small conferences were open to all, there would be no guarantee that the meetings would in fact be restricted in size and the object of the proposal might thus be defeated. This objection seems sound.

(2). An alternative suggestion put forward was that, in order that matters on which there were believed to be differences of opinion might be thrashed out, the staff should have round-table discussions with selected agricultural experts interested. This would be feasible though the selection of those who should attend would possibly be a matter of some delicacy.

(3) Mr. Scott has suggested the formation of a small Standing Sub-Committee containing representatives of up, mid and low-country, the Ceylon Estates Proprietary Association and the Tea Research Institute with power to co-opt others to enable matters of interest to be discussed as and when advisable between main conferences.

Mr. Scott will no doubt indicate in more detail the function of this proposed Committee. It might perhaps serve the purpose indicated in paragraph 2.

(4). Yet another suggestion put forward is that meetings should be arranged between Tea Research Institute's Staff, Visiting Agents and Colombo representatives.

(5). A further point for consideration is whether the interval of two years between main conferences is too long. One suggestion put forward is that conferences should be held each year, but that in alternate years the place of meeting should be somewhere, possibly Kandy, more convenient for mid and low-country planters than St. Coombs.

(6). It seems probable that some development on the lines indicated above may prove desirable but care should be taken to ensure that the conferences, sub-conferences, round-table talks, etc. all of which require considerable preparations, shall not absorb an undue proportion of the time of the technical staff.

(7). I have not dealt in this note with the question of the internal arrangements for the conferences. The experience of the last conference suggests, however, that more time must be available for actual discussion which can be achieved either by limiting the number of papers dealt with or by issuing the papers *in extenso* before the meeting when they would be taken as read.

(8). Arising from the last conference, reference must be made to the questions of special advisory officers and instructional courses.

The amount of advisory work continues to increase. At the present rate some reorganisation will in the not distant future have to be considered. Financial considerations would, however, appear to rule out the appointment of any additional staff for advisory work.

The question of instructional courses was mentioned by me at the conferences. I have not been approached further on the question by the Ceylon Planters' Society and the matter was only taken up by one speaker at the conference who thought the courses would have to be too limited in scope to serve a very useful purpose.

(Sgd.) ROLAND V. NORRIS,
Director.

March 20, 1939.

Enlarging on his memorandum, the DIRECTOR said there seemed to be a considerable measure of agreement that some kind of Liaison Committee consisting of the Tea Research Institute Staff, representatives of District Planters' Associations and of Colombo would serve a useful purpose in promoting closer contact between the Institute and Districts. Such a Committee would naturally meet only infrequently but the organisation would be available if anything of importance occurred which required joint consideration.

There was also the question of providing facilities for discussion in detail of problems on which differences of opinion might exist.

Mr. Scott had also suggested the formation of a Standing Committee and he would no doubt indicate what the function of this Committee would be.

In regard to the question of conferences at places other than St. Coombs, the DIRECTOR said he thought there was a good deal to be said in favour of this proposal.

MR. SCOTT said he thought the interval of two years between conferences was too long unless arrangements were provided to maintain contact meantime between the Institute and Districts. He strongly favoured setting up a Committee on the lines suggested. Such a Committee might meet once, or possibly twice, a year. It would not, therefore, cause undue interruption in the Institute's work but would keep the Institute and planting representatives in touch.

MR. KELLY thought a Liaison Committee would be unnecessary as it would always be possible when occasion arose for districts to ask the officers of the Institute to meet them in conference and it would be equally easy, when the desire was felt by the Institute, to ask the district or districts to appoint representatives to discuss a particular problem with the scientific officers. In this way the necessary conference could be arranged without the intervention of a Liaison Committee.

THE DIRECTOR explained the procedure in regard to the conferences held at Tocklai which, he stated, were not open to all but confined to the Tocklai Staff and nominated representatives of planting districts and Calcutta.

MR. CAMERON was doubtful how far the suggested Committee would serve the purpose desired and thought better results could be obtained by lectures and visits by the Staff in the districts.

THE CHAIRMAN in reply to Mr. Cameron, pointed out that the present proposals were to be additional to lectures and visits which were already provided.

MR. CAMERON asked whether in this case interference to research work would result.

MR SCOTT suggested that in regard to lectures, those attending were not perhaps always prepared to express an opinion at short notice on the issues raised. In the case of meetings held by the suggested Committee, representatives would come with definite instructions and it would be possible to reach some conclusion.

THE CHAIRMAN said there seemed to be agreement in principle to the setting up of machinery to maintain contact between conferences.

He personally wished to stress the importance of close liaison between the Institute, Visiting Agents and Colombo Firms.

The views expressed by members of the Board would now be considered and he and the Director would later make more specific proposals.

7. DISEASES AND PESTS

(a) *Phloem necrosis.*—The Board considered a resolution from the Nuwara Eliya District Planters' Association suggesting that additional staff should be engaged to enable more intensive work on *Phloem necrosis* to be carried out.

After discussion the Board approved proposals made by the Mycologist for the organisation of such work and agreed to approach the appropriate authorities in England to explore the possibility of obtaining the temporary services of a trained research scholar to carry out histological and cytological investigations in connexion with this disease.

(b) *Tortrix.*—Reported that the recommendation made by the Institute in regard to the temporary suspension of the regulations concerning Tortrix made under the Plant Protection Ordinance has been approved both by the Planters' Association of Ceylon and the Central Board of Agriculture.

THE DIRECTOR OF AGRICULTURE said he would take the necessary steps at an early date to give effect to this recommendation.

8. SENIOR SCIENTIFIC STAFF

Reported that Dr. Tubbs, Plant Physiologist, proceeded on home leave on 1st March.

9. JUNIOR STAFF PROVIDENT FUND

Mr. Kelly was elected to act as a Trustee during the absence of Mr. R. G. Coombe on leave.

10. ANY OTHER BUSINESS

(a). Reported that the Draft Report of the Board for 1938 was approved by circulation of papers (Circular No. A5/39 dated 2nd March, 1939.

(b). Reported that the Guest House was now open.

(c). *Research on the Chemistry of Tea.*—Reported that the Advisory Committee in London had recommended that Dr. A. E. Bradfield, D.Sc., of the University of Wales, Bangor, be appointed as Research Chemist under the Scheme for Research on the Chemistry

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon :—

(1) Mr. R. G. Coombe (on leave) Mr. Gordon Pyper (acting).

(2) Mr. Jas. Forbes, (Chairman)

(3) Mr. J. D. Hoare

(B) Representing the Ceylon Estates Proprietary Association :—

(4) Major J. W. Oldfield, C.M.G., O.B.E., M.C.

(5) Mr. I. L. Cameron

(6) Mr. J. C. Kelly

(C) Representing the Low-Country Products' Association :—

(7) Mr. S. F. H. Perera

(D) Representing the Small-Holders :—

(8) Mr. T. B. Panabokke

(E) Ex-Officio Members :—

(9) The Hon. the Financial Secretary.

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with the *Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being Rupees fifteen per annum for persons resident in Ceylon or India, and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*. In the case of Indian cheques four annas should be added to cover commission.